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The Microscope Drawing Tube Method (MDTM)
– an Easy and Efficient Way to Make Large Scale Die Studies

by

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The Microscope Drawing Tube Method (MDTM)

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SVEN AAGAARD and MICHAEL MÄRCHER¹

[PLATES 28–31]

Abstract: This article explains how die studies can be made on a large number of coins, even those with very similar dies, using the Microscope Drawing Tube Method (MDTM). Since the 1980s, the method has been used to identify the dies of more than 35,000 coins. It is an optical method, where die identification is made by the use of a stereo microscope equipped with a drawing device. To a large extent, the method eliminates the difficulties of traditional visual die identification.

Visual die identification

THE FIRST DIE STUDY was published in 1869.² It was conducted as a simple visual identification of the dies, and this is still the method employed in the vast majority of die studies, whether based on coins, photographs, plaster casts etc. The visual examination of dies was described by Kurt Regling as follows: ‘Man erkennt das nur durch genaueste Beobachtung zumal gleichgültiger und unwesentlicher Teile von Bild und Schrift, wie Stellung der Buchstaben und Interpunktionszeichen zueinander und zum Bilde’.³ Few publications describe their die study methodology, presumably because it is assumed that traditional visual die identification is used. François de Callatay mentions that the publication rate of die studies is increasing, and that there are at least 608 die studies of ancient Greek coins, but he also states: ‘In that respect, Greek numismatics is far ahead of the world of Roman numismatics, both Republican and Imperial, where die studies continue to be rare.’⁴

The fewer die studies of Roman coins may be due to difficulties with the visual method. Robert Bracey eloquently describes some of these difficulties: ‘Establishing a die identity is not entirely straightforward, as coins can rarely be directly compared. Traditionally casts were made for such work but digital photography has largely replaced that. Even so images vary in terms of lighting, scale and quality, as well as the general condition of the coin. It is possible to think two coins were struck from different dies when they were not, or to assign them to the same die when they were struck by different ones. Such errors are minimized by repeated checking but they can probably never be eliminated entirely.’⁵

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² Kleeberg 2005, p. 15.

³ Regling 1930, p. 660.

⁴ de Callatay 2005, p. 80.

⁵ Bracey 2009, p. 26, note 3.

When the number of dies used is modest, and the coin motifs are distinctly different, a visual identification is normally unproblematic. As the number of dies increases and/or the dies are more uniform, the time necessary and the uncertainty of the die identification grow exponentially. This is probably a key reason behind the fact that many important coin groups have not yet been subject to die studies. This fundamental problem in numismatic research can to some extent be eliminated with MDTM.⁶

When changing to the MDTM in 1999, Frank Pedersen found that about 5% of his previous and very careful die identifications carried out visually on an extensive and uniform coinage were incorrect.⁷

Microscope Drawing Tube Method (MDTM)

MDTM was published in Danish in 1984⁸ and has since been used to identify the dies of Danish-Norwegian coins dating mainly from the sixteenth to eighteenth centuries. It has also been used in a die study of nearly 950 coins of the Danish king, Niels (1104–34).⁹ Sven Aagaard and Pedersen have studied more than 35,000 coins, identifying and drawing over 13,000 dies using MDTM.

The microscope and the other equipment are shown in Figs 1–4 (**Pl. 28**). A more detailed description of the procedure is given in the user's manual at the end of the article.

The key feature of MDTM is that a drawing of a die can be produced in a fast and inexpensive way. Since most major coin cabinets have access to a stereo microscope, the introduction of MDTM only requires the purchase of the drawing device and, possibly, additional lens attachments and additional light sources. The equipment is portable. It fits into a couple of suitcases, thereby increasing its usability.

This method of making drawings, using a drawing device mounted on a stereo microscope, is not new and is used by, among others, zoologists to document the anatomical details of insects and other small animals. The significant new element of MDTM in numismatics is that it is used to compare the die drawing with new coins, photographs etc. placed under the microscope. The die drawing thereby becomes *a tool* to make die identifications rather than just being a simple drawing of a die.

Some numismatists may find the idea of drawing coins / dies alien but the method cannot be compared with an artist's drawing; rather it is like a simple tracing. MDTM requires no prerequisites and can be used by non-professional personnel. Aagaard

⁶ For a computer based methodology using the digital over-lay method, where the die comparison is made by superimposing the digital photographs in image editing software, see Jensen and Skjoldager 2009. This method, among other things, has the advantage of being digital and, in comparison with the material costs for MDTM, it is cheaper. On the other hand it seems to be operationally slower than MDTM on the basis of the method description. See for example Stannard and Fischer-Bossert 2011; and Ariel and Fontanille 2011.

⁷ Frank Pedersen, personal communication. The coin type was the Danish-Norwegian copper 1 skilling 1771: about 55 million coins were struck at three different mints from 1771 to 1785 with an immobilised date and motif, Hede 1978, no. 37.

⁸ Aagaard 1984 and 1994c.

⁹ Aagaard, Bolt Jørgensen and Märcher, unpublished ongoing investigations of Danish coins from c. 1095–1134, for example, die studies of Niels, (Hauberg 1900, pp. 231–2, pl. 13, no. 9). See Märcher, Aagaard, Bolt Jørgensen (2017).

has found that children and other untrained persons can use the drawing device after a short instruction.

In the absolute sense die drawings are not *correct* die reproductions, since they merely illustrate the estimated dividing line between the coin's motif and the coin's surface. For coins struck by hammer or in rolling mills and Taschenwerke this dividing line will show small variations determined by the depth of the strike and the degree of die wear. The advantage with MDTM is that the die drawing always gives a true representation of the *relative* distance between the single elements of the coin motif.¹⁰

The future use of each individual drawing depends on the care taken to make it. MDTM can be used to produce very precise, professional drawings, but less professional drawings will usually be fully satisfactory for making die identifications. A selection of die-drawings is shown in Fig. 13 (Pls 29-31). It is generally recommended to make complete drawings of the coins, as it facilitates the selection of possible dies from the pool of already produced die drawings when a new coin is to be identified. Furthermore, both complete die drawings and drawings of die details can be used directly as illustrations in publications.

MDTM makes it possible to identify the dies of heavily worn or corroded coins, and fragments, which cannot be identified visually. Aagaard, for example, had no problems identifying the dies of several corroded coin fragments from the Danish warship, Dannebrog, which exploded and sank during a naval battle in 1710 (Fig. 5).



¹⁰ Double struck coins are initially excluded in the hope that the die will be found later on a well struck specimen.

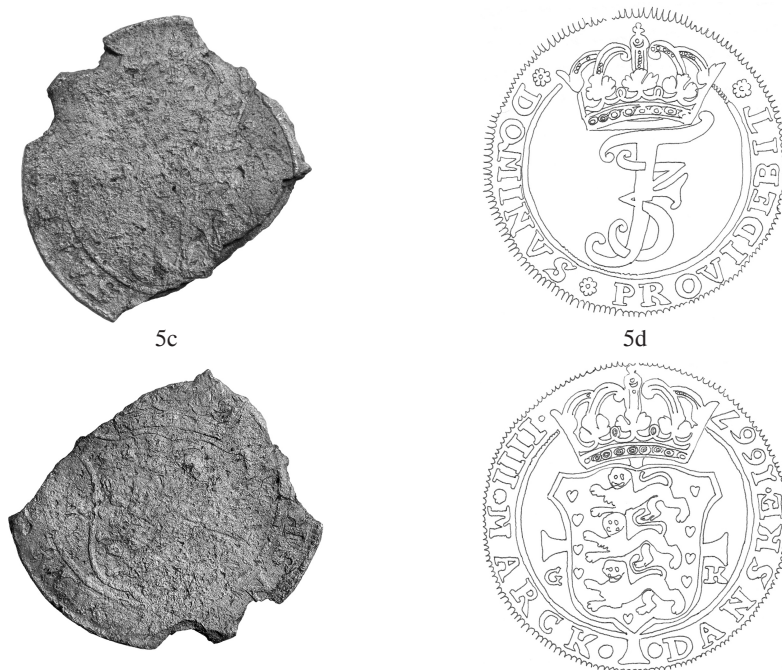


Fig. 5. Coin fragments from the Dannebrog-hoard, which were easily die identified with MDTM. Small fragment from 1668. (Aagaard T 116.2 die combination 68-GK15/68-GK11), 5.11 g. Large fragment from 1667 (Aagaard T105.4 die combination 67-GK7/67-GK, 9), 9.48 g. The Royal Collection of Coins and Medals, FP 4518.43 and FP 4518.52, Aagaard (2011).

The method has, furthermore, been used to identify the dies of coin fragments found by metal detectorists, making their identification more accurate (Fig. 6).



Fig. 6. Detector-found fragment of a cast counterfeit coin, 4 mark 1672, which was easily die identified with MDTM. 3.11 g. The Royal Collection of Coins and Medals, FP 8026, Aagaard (2009). (1.5x)

Another important benefit of MDTM is that the person drawing the dies becomes much more familiar with all the details of the coin motif than they would be by visual comparison of coins, photographs, etc.

Finally, MDTM has the advantage that one can put a coin or photograph aside, once its dies have been identified, since one ends up with a file of die drawings and a list of results. The die drawings can be scanned to document the dies, while the die data can be put into database software to sort out the die combinations and the subsequent production of die chains (Fig. 7).

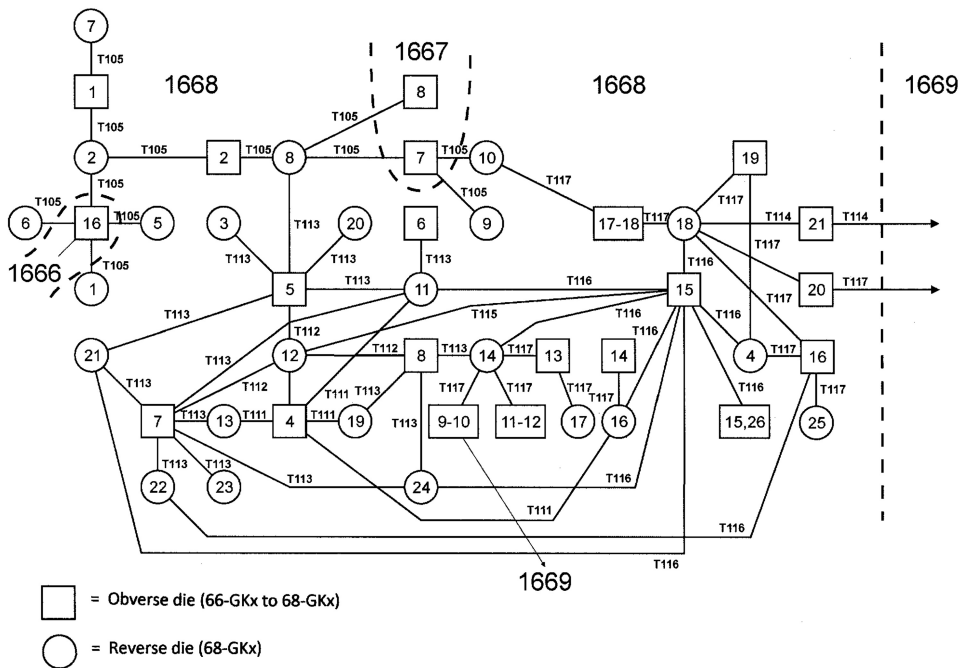


Fig. 7. Example of die links of 4 mark (crowns) minted in Copenhagen 1668. (Aagaard 2004, p. 188, fig. 13).

The traditional, visual, die comparison is physically demanding and tiring, which can slow down the process and give unreliable results, even after a relatively short time. MDTM has the great advantage that the die identity is recorded mechanically with no subjective interpretation required. The overlapping of a coin, photo, impression etc. under the microscope and a die drawing under the mirror seen in the oculars (eyepieces) is an almost miraculous highlighting of the die's contours. The eyes and brain are therefore not tired by the constant scanning of two coins or photographs for die details to determine if there really is die identity or not (see the above quote by Bracey). This has the positive impact that one can with ease, of course with appropriate breaks, work long hours every day and process a large body of material in a relatively short time.

In the case of a large number of coins with many, very similar, dies the time required of course grows by the number of dies involved. The same problem applies, but even more so, when using the traditional method of comparison. A visual identification of dies may prove impossible if the differences between dies are minimal, such as the spacing between letters or elements of the motif. MDTM was on the other hand recently used to identify and draw 96 obverse dies and 146 text identical reverse dies from more than 500 specimens of a Danish 6 skilling 1629 (Fig. 8), primarily from two Danish hoards deposited c.1657. The total time taken was about 300 hours.¹¹ A die study of this size and complexity could hardly be done by traditional visual comparison.

¹¹ Aagaard and Märcher in preparation-a and -b.



Fig. 8. Danish 6 skilling 1629.

Other uses of MDTM

Die flaw analysis¹² is more easily made with MDTM than by using photographs as the size and distribution of the die flaws on different die identical coins can immediately be documented and disseminated (Fig. 9).

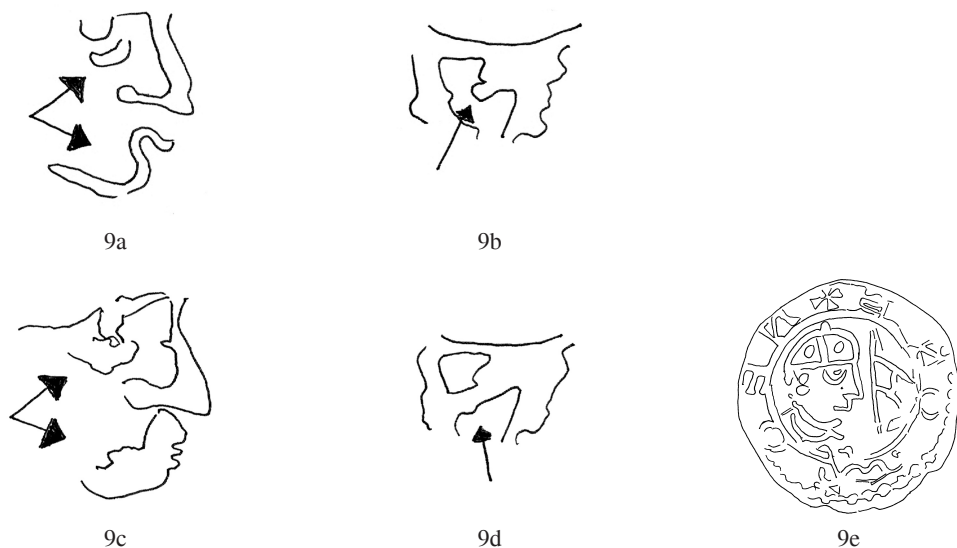


Fig. 9. Two examples of die cracks on obverse dies used to strike Danish twelfth century pennies (Niels (1103–34). Hauberg 1900, pp. 231–2, pl. 13, no. 9).

The first two drawings show die details before the crack evolved, the last two drawings show the development of die cracks. The third and central drawing illustrates the obverse type.

The same applies to the identification of letter and picture punches. Using MDTM, Aagaard has documented that the medallist Anton Meybusch first used a coarse portrait punch, which he later refined, when engraving the king's portrait on an important series of coins from 1693 to 1699 (Hede 1978, nos 99–114).¹³

Furthermore, MDTM makes it possible to reconstruct dies¹⁴ from a number of badly preserved die identical coins (see Fig. 10 on **Pl. 29**).

¹² E.g. Aagaard 2003.

¹³ Aagaard 2010b.

¹⁴ E.g. Märcher and Aagaard 2014b.

Finally MDTM makes it easier for groups of people to collaborate on die studies through the exchange of scans of drawings. In standard software drawings can be scaled to the preferred magnification if the only available stereo microscope has fixed magnifications.

Ancient coins

MDTM has been little used on ancient coins, but the method can probably be used on most coin types. Coins with plastic relief are more difficult, since the separation line between the motif and the coin's surface is not well defined, but this does not prohibit the use of MDTM. MDTM may be used to trace the well-defined points of the die, rather than the outline of the plastic motif, and the relative position of these elements can then be used for die identification.

Even if MDTM is not used fully, the drawing device can be used in combination with the visual method to compare dies, coins, impressions etc. MDTM has been used in a study of the pottery 'Arethusa cups' which were decorated with medallions made from impressions of coins.¹⁵ The stereo microscope was used to draw prominent features of the medallion decoration of the cups in order to distinguish between the different clay moulds used for the medallion, and the Syracusan decadrachms from which the moulds were taken. This simplified use of the method facilitated the visual comparison of images made in different materials and – due to the shrinkage of the clay – slightly different sizes.

Results obtained with MDTM

Studies using MDTM have resulted in detailed overall descriptions of the groups of coins examined, including die chains, revised typologies, checking and adjusting of mint accounts, estimation of the average life of coin dies etc. including what Bracey calls inter-die analysis, intra-die analysis, and meta-die analysis.¹⁶ Aagaard has primarily worked on Danish-Norwegian coins from the sixteenth to seventeenth centuries, but older Swedish coins have also been examined.¹⁷

The results have been crucial to the research into the monetary history of these periods, with regard to the process, volume, and structure of the period's coin production as well as to mint attributions, engraver attributions, dating, minting technology and much more detailed typologies for a very large number of coin types.

A specific result can serve as an example of the cultural and historical importance of the use of MDTM. While working with larger Danish-Norwegian silver coins from the second half of the seventeenth century, Aagaard was able to identify a large group of contemporary, very well made counterfeit kroner (crowns = 4 marck, Fig. 11).

¹⁵ Horsnæs 2000 and Horsnæs personal communication.

¹⁶ Bracey 2009, p. 26.

¹⁷ Aagaard 1985, 1996–1999, 2004 and 2011; Märcher and Aagaard 2012; Bondeson, Bondesson and Märcher 2013.



Fig. 11. Official and counterfeit krone 1669, Christiania (Oslo, Hede 1978, no. 66 and MC69-1). The photo in Holger Hede's standard work from the 1960–70s on Danish-Norwegian coins erroneously shows (p. 121) the counterfeit coin.

There were no die links between this group and the larger group of official coins. The counterfeit coins were machine struck, perhaps at an official mint(s) in Northern Germany, with fixed die axes and included the use of at least 36 dies. This counterfeiting, which seems to have been quickly discovered in the Danish realm and led to the prohibition of the import of the coin type in general, must therefore have been on a significant scale. It took more than 300 years and MDTM, though, to rediscover the exact group of coins and separate them from the official ones. In numismatic literature these counterfeit coins are known as *mystery crowns*.¹⁸

MDTM has also been used by other scholars,¹⁹ especially Pedersen²⁰ who conducted a detailed overall catalogue of the coins produced during the reign of the Danish-Norwegian king, Christian VII (1766–1808). His die studies have revolutionized and revised all the period's many coin typologies and include important contributions to Danish-Norwegian monetary history.

¹⁸ Aagaard 1994a-b and 2010a; Märcher and Aagaard 2013 and 2014a.

¹⁹ MDTM has been used in the following studies: Kurt Guldberg 1996–2000 on Danish-Norwegian coins of Frederick IV (1699–1730), Moesgaard 2007 on 63 imitations of English coins (Edward the Confessor, expanding cross type) from a Danish hoard consisting of 72 coins from the eleventh century, Märcher 2015, on coins in the Magleby hoard (680 coins, tpq 1535) and Märcher, ongoing studies on Danish twelfth century coinage.

²⁰ Pedersen forthcoming combines die studies with extensive archival studies. A significant number of specialised studies have appeared in articles, see Pedersen's bibliography in Nielsen 2011.

USERS' MANUAL

Preparation of study material

Larger die studies will nearly always be based on material gathered from multiple locations.²¹ Typically, this will include coins in a museum's collection including relevant hoards, supplemented by pictures of coins from other museum collections, private collections, auctions catalogues, sales lists, literature etc.



Fig. 12. Example of benchmarks and connecting lines in a (drawn) die, which could be used to perform the Angle Sorting Method (ASM) as a part of a complex die study.

Very dark coins and heavily cleaned silver coins can be difficult to identify, even with MDTM. Here it is recommended to make an impression of the coin, which can be used as basis for the die drawing.

If coin photographs are in a format non-compatible with the microscope, it may be necessary to scan them and scale them to the correct size.

Regardless of the material and the nature of the preparation of the study material, drawing should obviously start with the specimens showing the best die representation.

Stereo microscope

Modern professional stereo microscopes are available with either fixed magnification or zoom functions. Optimal working conditions when drawing are obtained when the coin fills approximately two-thirds of the view in the microscope. This requirement will generally be met with a microscope with zoom function, whereas for a microscope with fixed magnification it may be necessary to use a supplementary lens attachment, which also involves a change in the working position. When purchasing a microscope with fixed magnifications, one should always be sure that the working position is acceptable. Otherwise, one should choose a microscope with zoom function.

²¹ If the study material includes a large quantity of very similar coins and a large number of dies is expected, it may be necessary to use an IT-based method for sorting the dies in advance. This can be done by the *Angle Sorting Method (ASM)* which exploits the differences in the angles between selected benchmarks in the dies/motifs. The method, which is not yet fully developed or tested, is the process whereby an image of a coin, plaster cast, impression etc. is transferred to an electronic screen where the examiner, with an electronic pen, marks the position of predetermined benchmarks in the die / motif. Corresponding software then groups the coins according to the size of the angles between the benchmarks or between associated connecting lines (Fig. 12). The method has the advantage of not requiring the coins to be of a known size, so photographs from auction catalogues, for example, may easily be used. Sorting could be refined by increasing the number of benchmarks and/or connecting lines.

Working position

The drawing of dies can, after prolonged work, cause muscle pains in the shoulder and hand. Therefore, it is important that the working position is pleasant, and that the arms get natural support from the table while working.

Lighting

MDTM requires an extra bright light that can be easily adjusted. This applies both under the microscope and in the work area. The normal microscope lamp that comes with the microscope is not bright enough. Instead it is advisable to use a cold-light-lamp as shown in Fig. 2. The lamp has two flexible, adjustable arms, and it comes with optional colour filters.

To light up the working field a small and lightweight portable halogen lamp is preferred (Fig. 2 on **Pl. 28**).

Experience shows that it is crucial that both light sources are easy to adjust during drawing and preferably without moving the eyes away from the eye pieces. With some practice, the adjustment is more or less done automatically by reflex.

Finally, it is important that any disturbing light sources are removed, but it is not recommended to work in a completely darkened room.

Adjusting the microscope

It is of vital importance for the use of MDTM that the microscope is adjusted correctly and that the lighting of the coin and drawing area is appropriately aligned.

The microscope must be set to one's individual eyesight without the drawing device mounted. A coin is placed under the microscope. The right eye piece is removed. The left is turned to zero. The microscope is then focused on the coin. The right eye piece is mounted, and the left eye is kept closed and the right eye piece is adjusted by turning it. Now the coin under the microscope should be seen sharp and clear with both eyes.

Adjusting the drawing device

A piece of drawing paper is placed under the mirror of the drawing device and illuminated with the separate halogen lamp. The tip of a pencil is put down on the paper so it can be seen through the eye pieces. If the tip or the subsequent drawing appears blurred in the eye pieces, adjust the mirror of the drawing device by turning the device's focussing screw. If the two light sources are appropriately balanced, it will now be possible to draw a coin/die, while one clearly follows the drawing movements in the eye pieces.

Drawing surface

While drawing it is better for the paper to rest on a surface such as a thin, soft cardboard sheet from the back of an A4 paper pad rather than directly on a hard table surface.

Drawing paper

Aagaard always uses simple white copy paper, which can be purchased in packs of 500 sheets. If one expects to store and use the drawings for decades or exchange them with other people, it would be wise to choose paper of higher quality. The important requirement is that the paper is easy to draw on with the selected drawing tool. This means that the pen should move across the paper without experiencing any resistance from the paper, and the paper's structure should be sufficiently non-porous, so the lines do not blur.

For smaller coins without a very detailed coin image, it is recommended to work with drawing paper of A5 size, which is also easier than A4 to handle during the die identification process.

Fastening the paper

The paper is kept in place with paper weights or other easily removable items so that during work it is easy and fast to change and move the paper.

Drawing tool

It is strongly recommended that drawings are made directly with a marking pen without a previous pencil drawing. The latter is time consuming, and carries the risk of mistakes because the subsequent pen drawing is done away from the microscope.

Aagaard has always used a black, water-based 0.5 mm marking pen, type Pilot V5 HI-TECPOINT, which has the advantage that it is both lightweight and has a smooth surface so it does not wear out your fingers. The cap should be removed and not placed on the end of the marking pen, so that the hand's mobility is the best possible during drawing. These Pilot marking pens are furthermore beneficial since they have a thin metal tip, which makes it easier to see the tip of the pen in the microscope during drawing.

For more durable die drawings, one could select a marking pen with copy ink.

Hand protection against wear

Many hours of drawing will cause wear on the hands due to the skin's contact with the paper and drawing surface. To avoid this, Aagaard uses simple, white museum gloves of cotton, where the outer half of the three working fingers are cut off. Cotton gloves also have the advantage that the drawing paper is protected against moisture from the hands.

How do you draw?

Aagaard normally starts by drawing the circumference of the coin, as well as significant benchmarks in the die such as punctuation marks in the margin. This ensures that there is no problem moving the drawing back into place if the position of the coin under the microscope is disturbed during drawing. Otherwise, drawing is done with a sweeping motion, where the individual components in the motif are

drawn with as little disruption as possible. It is best to move the hand around the coin image, in order to vary the hand position, so the drawing is not necessarily built systematically from one side.

What do you draw?

One primarily draws the contours of the motif where the coin is not damaged or worn. For larger die studies one can hope to retrieve the die from other coins and possibly complete the first drawing in order to achieve as ideal an image of the die as possible.

With experience one can recognize and draw die flaws, which eases die identification and can be crucial for subsequent determination of chronologies. One should always be aware that die flaws usually develop during use of the die, so it is possible to find the same die without flaws.

The drawings should be understood as result sheets, so notes and larger, detailed drawings of parts of the die can be added so that all relevant information about the specific die is kept together.

Comparison of coins with die drawings

Comparison takes place in its simplest form by putting one die drawing after the other under the mirror until die identity is established with the coin under the microscope. If the die is not known, it is drawn. If there is a large pool of die drawings it can be an advantage, before die identification, to note the relative position of important elements of the design, since it is then easier to locate the die. Possible dies can also be found from lists of already known die links.

Numbering the dies

One should use as simple a numbering system as possible to minimize errors during the die identification. The prefixes, obverse and reverse (or abbreviations), may not be necessary unless there is doubt about which is the obverse and reverse motif. If the result should later be translated into official multi-digit die numbers or codes, this can be done using a concordance list.

KEY TO ILLUSTRATIONS

Pls 28–31 (all other figures are in the text).

Fig. 1. Stereo microscope model SMC4 with mounted drawing device (drawing tube) to the right. Manufactured by Mikroskop Technik Rathenow GmbH, Grünauer Fenn 40, D-14712 Rathenow, Germany, mikro.ra@askania.de, www.askania.de. Figs 1–4, photos: Inger Bolt Jørgensen.

Fig. 2. Place of work showing drawing pad, drawing paper, moveable glass weights, adapted cotton gloves, moveable halogen lamp and the moveable arms of the cold-light-lamp model jenalux 150.

Fig. 3. Drawing device. Note the diagonal mirror to the right, which transfers an image of the drawing so it can be seen through the eye pieces overlaid on the coin/photo etc. under the microscope.

Fig. 4. Aagaard using MDTM.

Fig. 10. Five die-identical counterfeit Danish coins from the twelfth century (Hauberg 1900, Niels, p. 230, pl. 13, no. 2) found with a metal detector on Bornholm. The almost complete dies are reconstructed from the five coins using MDTM. Photos: Karsten Kold. (All 1.5x)

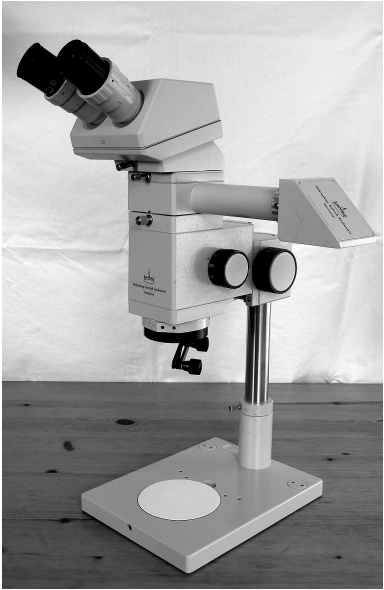
Fig. 13. Die drawings of different types of ancient, medieval, and early modern coins made by the use of MDTM. Required time from 5 to 30 minutes per drawing. Most drawings are enlarged compared to the coins.

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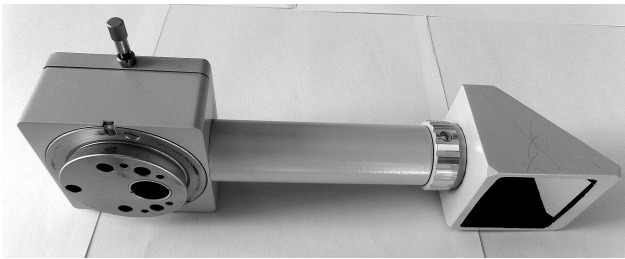
PLATE 28



1

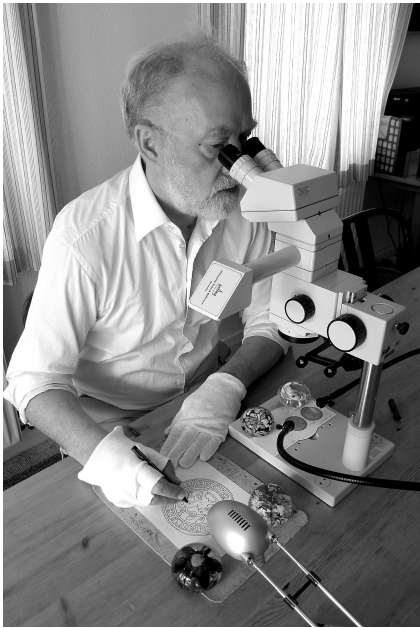


2



3

4



AAGAARD and MÄRCHER, THE MICROSCOPE DRAWING TUBE METHOD (MDTM) (1)



10.1



10.2



10.3



10.4



10.5



10.6



13.1



13.2



13.3



PLATE 30



13.4



13.5



13.6



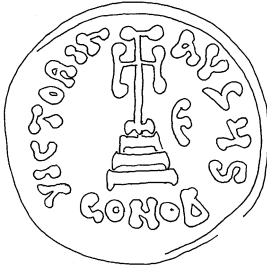
13.7



13.8

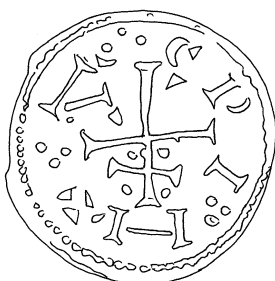


13.9





13.10



13.11



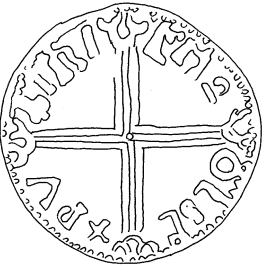
13.12



13.13



13.14



13.15



